Weekly Updates (12/10/2023) – Krishna Tarun Saikonda

The main objective of this report is to conduct multiple traffic simulations while altering various parameters and subsequently examine the outcomes, with a particular focus on collision-related data. I conducted 10 simulations for each parameter value, varying tau, collisionmingap, sigmaerror, and emergency deceleration.

In our simulation, we have defined various vehicle types ('vType') and traffic flows ('flow') as parameters for SUMO simulations. Here's an overview of the two defined vehicle types and their characteristics:

1. DEFAULT_KRAUSS: This vehicle type represents a yellow vehicle with various characteristics. It is designed to operate in a way that does not typically lead to collisions.

2. DEFAULT_VEHTYPE: This vehicle type represents a red vehicle with slightly different characteristics. Unlike DEFAULT_KRAUSS, DEFAULT_VEHTYPE is designed in a manner that may lead to collisions, and its behavior changes accordingly.

Additionally, there are 10 vehicle flows defined in our simulation, which specify the routes that vehicles will follow within the simulation. These flows can include a mix of both DEFAULT_KRAUSS and EGO_VEHTYPE vehicles, and their routes and interactions will depend on the flow definitions provided in the simulation.

Flow ID	Type	Begin	From	To	End	Number
f_0	DEFAULT_VEHTYPE	0.00	E0	E2	300.00	500
f_1_k	DEFAULT_KRAUSS	0.00	E5	E2	300.00	250
f_1	DEFAULT_VEHTYPE	0.00	E5	E2	300.00	500
f_2_k	DEFAULT_KRAUSS	0.00	E0	E6	300.00	250
f_2	DEFAULT_VEHTYPE	0.00	E0	E6	300.00	500
f_3_k	DEFAULT_KRAUSS	0.00	-E2	-E0	300.00	250
f_3	DEFAULT_VEHTYPE	0.00	-E2	-E0	300.00	500
f_4_k	DEFAULT_KRAUSS	0.00	E7	-E0	300.00	250
f_4	DEFAULT_VEHTYPE	0.00	E7	-E0	300.00	500
f_5_k	DEFAULT_KRAUSS	0.00	-E2	E8	300.00	250
f_5	DEFAULT_VEHTYPE	0.00	-E2	E8	600.00	500

SCENARIO 1 - Examining the Mean and Variance of each parameter value through the execution of the simulation ten times for each parameter.

In this scenario, we investigate collisions between Default and ego vehicles on a highway. We systematically modify a single simulation attribute at a time to identify which parameters are responsible for causing these collisions.

During our in-depth analysis of crash scenarios in a highway simulation, we scrutinized various parameters that influence different types of collisions, including intersection, lane-switching, and rear-end incidents. Notably, we found that the parameters 'tau,' 'collisionMinGapFactor,' 'sigmaerror,' 'sigmagap,' and 'lcooperative' play critical roles in determining the nature and frequency of these incidents. These parameters are particularly significant within the EIDM car-following model, as they strongly impact the outcomes of diverse collision situations. This highlights the importance of carefully fine-tuning and optimizing these specific parameters to enhance traffic safety and reduce the risks of various collisions in simulated environments.

I conducted an analysis where I calculated both the mean (average) and variance (measure of data spread) for the specified parameters across 10 simulations. The results were then plotted to illustrate how these parameters' values change from one simulation to another, giving us insights into the variability within the data for each simulation.

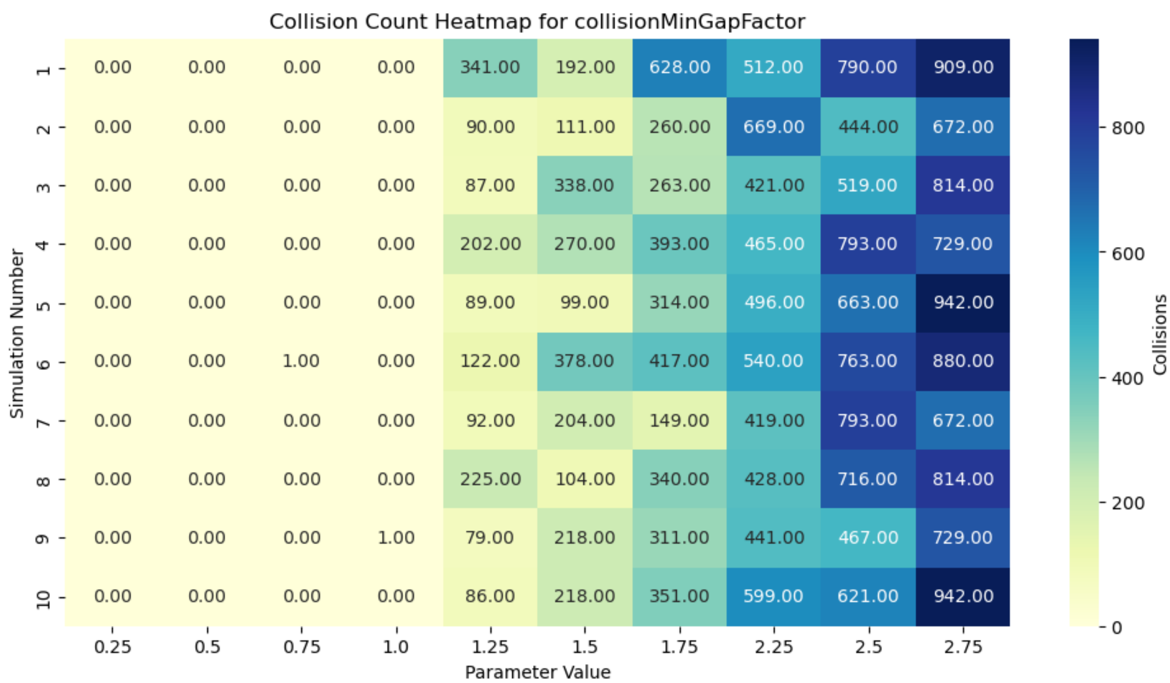
Results:

CollisionMinGapFactor:

Collision Count Heatmap:

The heatmap, which is like a color-coded grid, to help us see how collisions change across different simulations and for different values of a parameter (in this case, " CollisionMinGapFactor "). The rows in the heatmap represent different simulations, and the columns represent different parameter values.

The color of each cell in the heatmap shows the number of collisions in a particular simulation with a specific parameter value. Darker colors indicate more collisions, while lighter colors mean fewer collisions. This way, we can easily see which parameter values and simulations lead to more or fewer collisions.

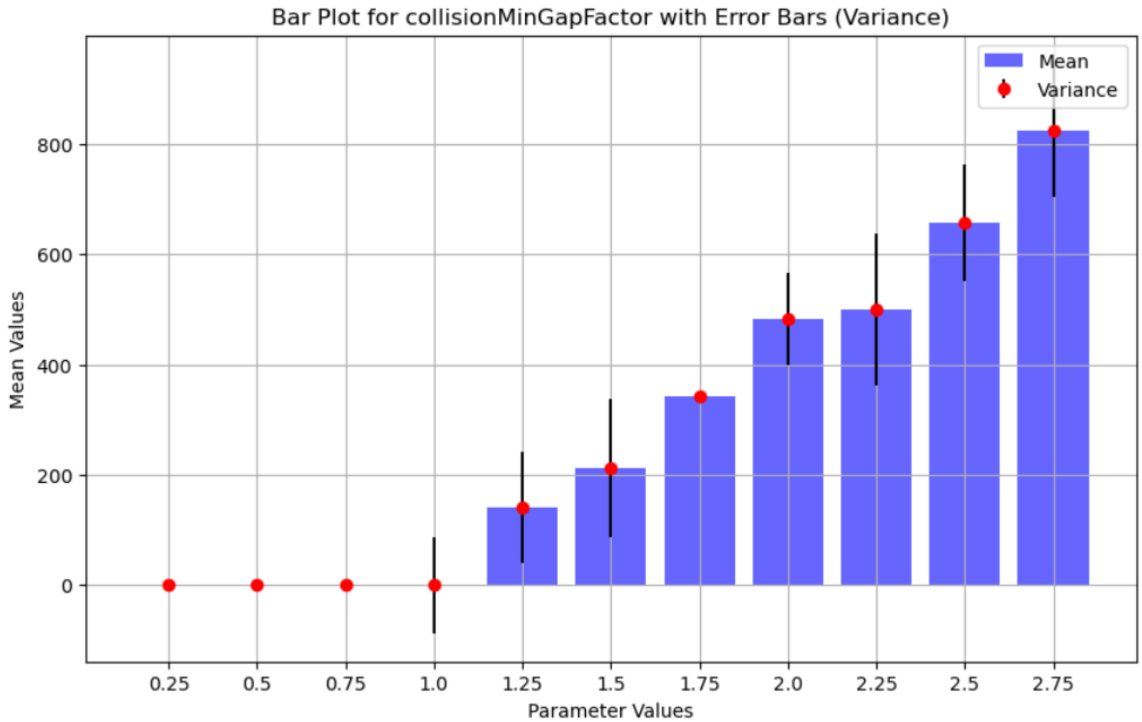


Simulation Number	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.25	2.5	2.75
1	0.00	0.00	0.00	0.00	341.00	192.00	628.00	512.00	790.00	909.00
2	0.00	0.00	0.00	0.00	90.00	111.00	260.00	669.00	444.00	672.00
3	0.00	0.00	0.00	0.00	87.00	338.00	263.00	421.00	519.00	814.00
4	0.00	0.00	0.00	0.00	202.00	270.00	393.00	465.00	793.00	729.00
5	0.00	0.00	0.00	0.00	89.00	99.00	314.00	496.00	663.00	942.00
6	0.00	0.00	1.00	0.00	122.00	378.00	417.00	540.00	763.00	880.00
7	0.00	0.00	0.00	0.00	92.00	204.00	149.00	419.00	793.00	672.00
8	0.00	0.00	0.00	0.00	225.00	104.00	340.00	428.00	716.00	814.00
9	0.00	0.00	0.00	1.00	79.00	218.00	311.00	441.00	467.00	729.00
10	0.00	0.00	0.00	0.00	86.00	218.00	351.00	599.00	621.00	942.00

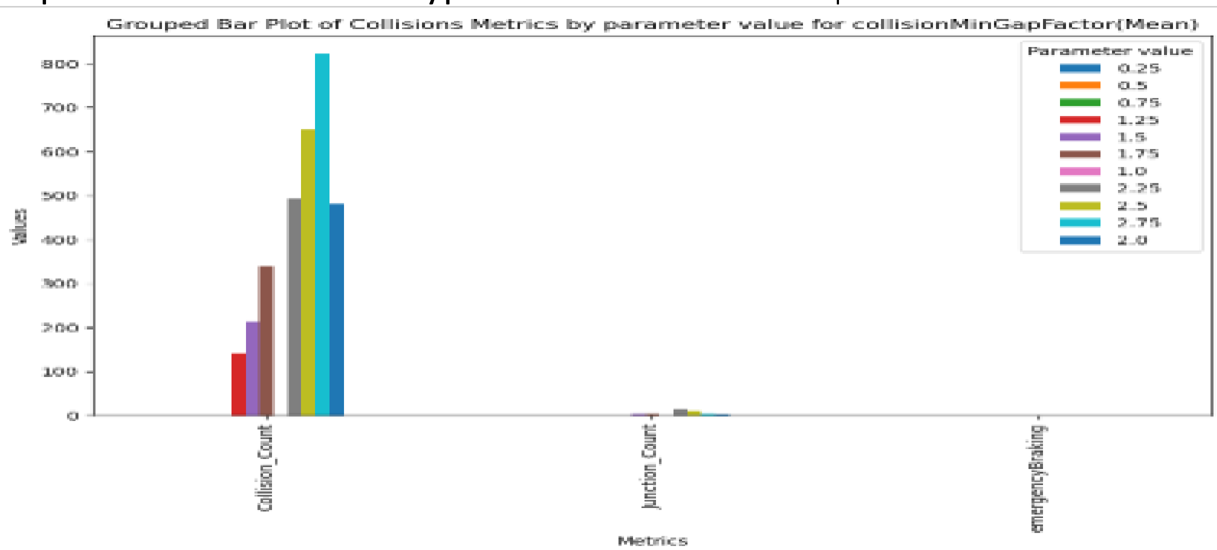
Collision Count Bar Plot for CollisionMinGapFactor**:**

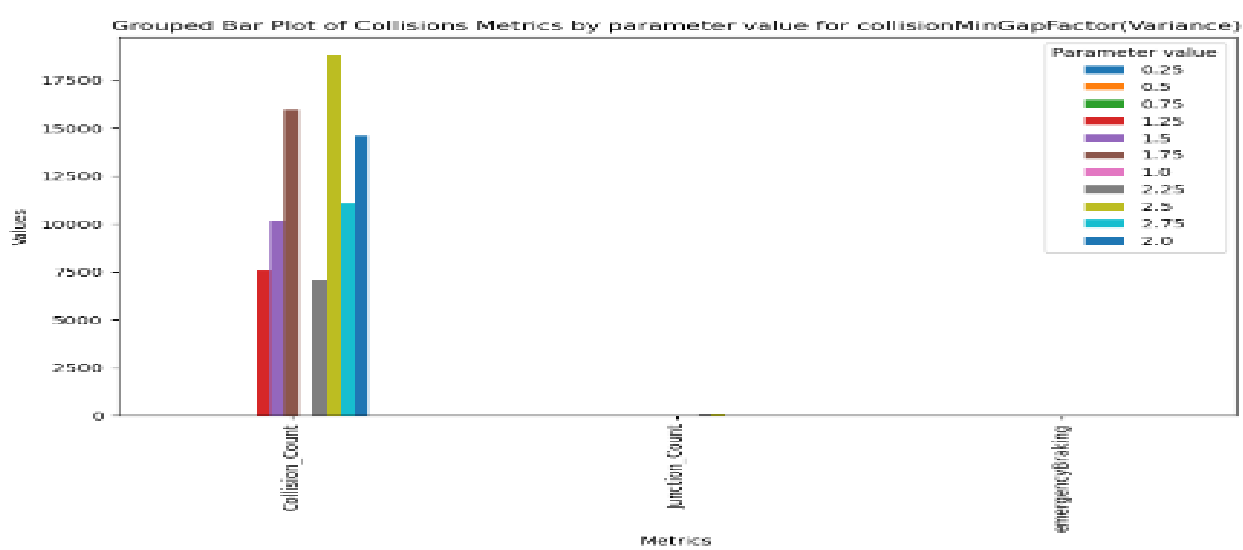
The analysis of the "Collisions" data reveals insightful patterns in both the mean and variance for different parameter values. When examining the mean data, it becomes evident that lower parameter values, ranging from 0.25 to 0.75, consistently result in minimal collisions, almost close to zero, indicating a low probability of collision incidents. Even at a parameter value of 1.0, the average number of collisions remains low, signifying a relatively collision-free simulation environment. However, a significant shift occurs at a parameter value of 1.25, where the average number of collisions sharply increases to 141.1, suggesting a noteworthy uptick in collision incidents. As the parameter values rise further, from 1.5 to 2.5, the average number of collisions continues to escalate, implying that higher parameter values lead to more frequent collisions.

The variance data offers additional insights into the variability of collision outcomes for these parameter values. In the case of parameter values ranging from 0.25 to 0.75, the variance remains minimal, signifying a consistent number of collisions without significant fluctuations. At a parameter value of 1.0, the variance remains low, indicating a relatively stable collision pattern. However, as the parameter value increases to 1.25, the variance shows a slight uptick, suggesting that the number of collisions may vary slightly across different simulations. This trend of increasing variability becomes more pronounced as the parameter values climb from 1.5 to 2.5. Here, the variance is notably higher, indicating a broader range of collision outcomes. In summary, this analysis highlights the critical relationship between parameter values and collision incidents, underlining the importance of carefully selecting these values to control and predict collision outcomes within simulated scenarios.



Grouped Bar Plot of Collisions Metrics by parameter value for CollisionMinGapFactor**:**





The analysis of both mean and variance data highlights the notable influence of parameter values on critical simulation factors, including "Collisions Count," "Junction Count," and "Emergency Braking."

In the case of "Collisions Count," as parameter values escalate, there is a clear upward trend in the mean number of collisions, with a substantial leap observed at a parameter value of 1.25. Simultaneously, the variance in "Collisions Count" increases, indicating a broader range of collision counts across different simulations.

Similarly, the "Junction Count" displays a rising mean count with higher parameter values, reflecting an increasing number of junction incidents in the simulations. The corresponding variance also amplifies, revealing more significant variability in the frequency of junction incidents across simulations.

For "Emergency Braking," a similar pattern emerges, where mean counts of emergency braking events rise with increased parameter values. The variance in "Emergency Braking" data reflects heightened variability in the frequency of these events, particularly at higher parameter values.

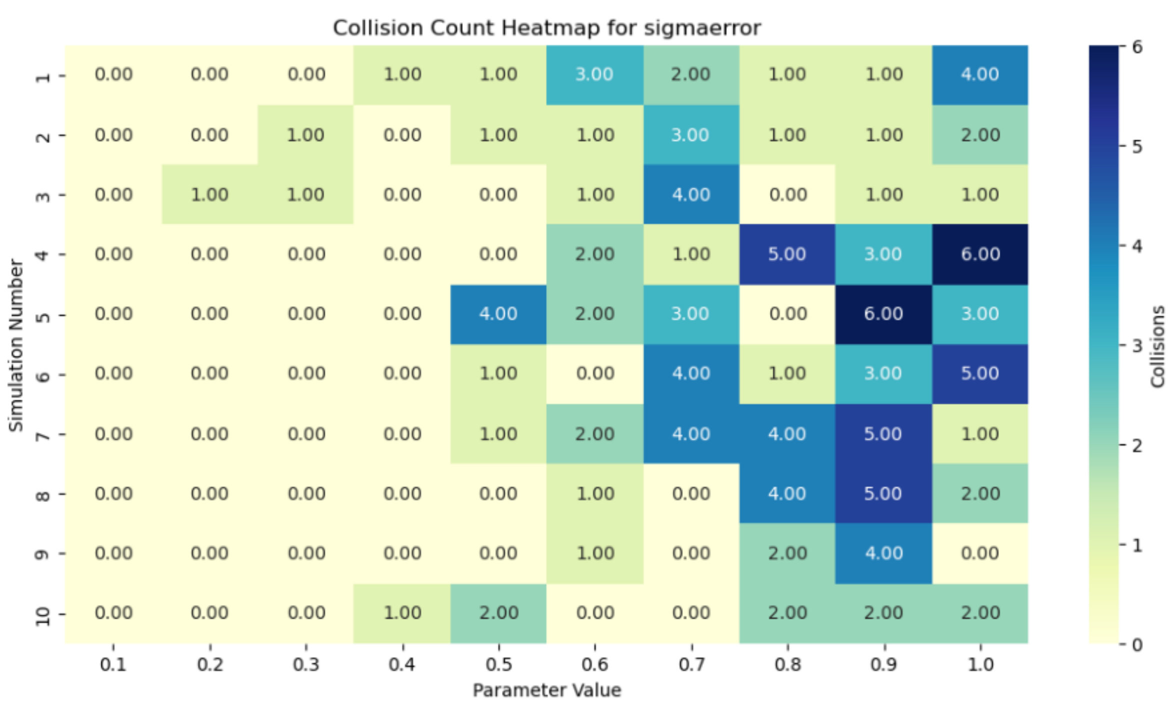
In summary, this analysis underscores the critical impact of parameter values on the occurrences of collision counts, junction incidents, and emergency braking events within the simulations. As parameter values increase, not only do the mean counts tend to rise, but the variance also grows, highlighting the necessity of thoughtful parameter selection to effectively control and predict these vital simulation factors.

Sigma Error:

Collision Count Heatmap:

The heatmap, which is like a color-coded grid, to help us see how collisions change across different simulations and for different values of a parameter (in this case, "SigmaError"). The rows in the heatmap represent different simulations, and the columns represent different parameter values.

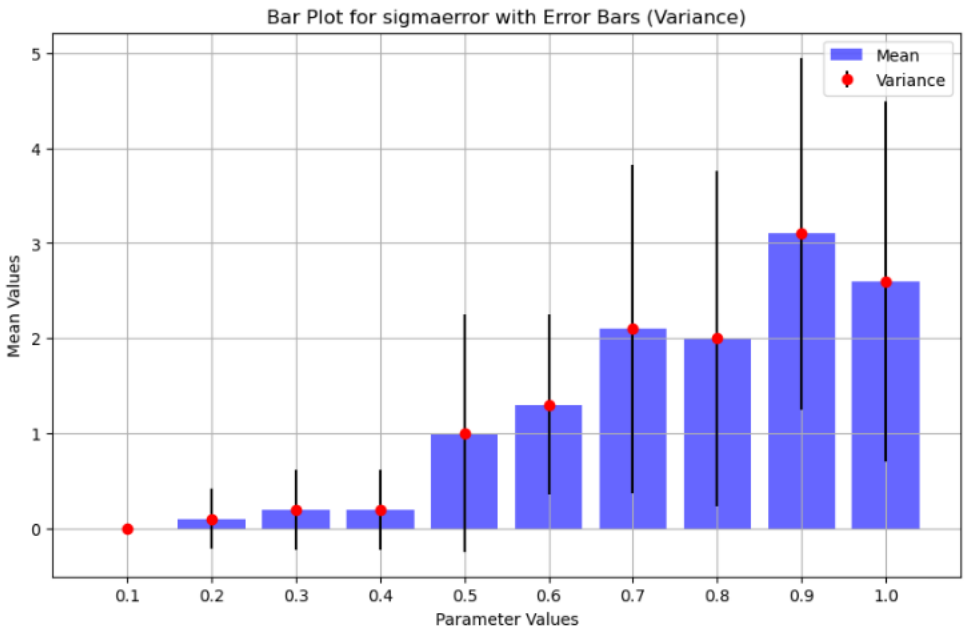
The color of each cell in the heatmap shows the number of collisions in a particular simulation with a specific parameter value. Darker colors indicate more collisions, while lighter colors mean fewer collisions. This way, we can easily see which parameter values and simulations lead to more or fewer collisions.



Collision Count Bar Plot for SigmaError**:**

The analysis of "Collisions" data, concerning the "sigmaerror" parameter, reveals a significant relationship between parameter values and collision occurrences. The mean analysis demonstrates that as "sigmaerror" values increase from 0.1 to 1, the average number of collisions also rises, indicating a direct positive correlation between the parameter and the frequency of collisions.

Simultaneously, the variance analysis illustrates an increasing spread in collision counts as "sigmaerror" values advance. This suggests not only a higher incidence of collisions but also a broader range of outcomes in different simulations. These findings emphasize the crucial role of "sigmaerror" in influencing both the mean and variability of collision occurrences, underscoring the importance of parameter selection in traffic simulation outcomes.



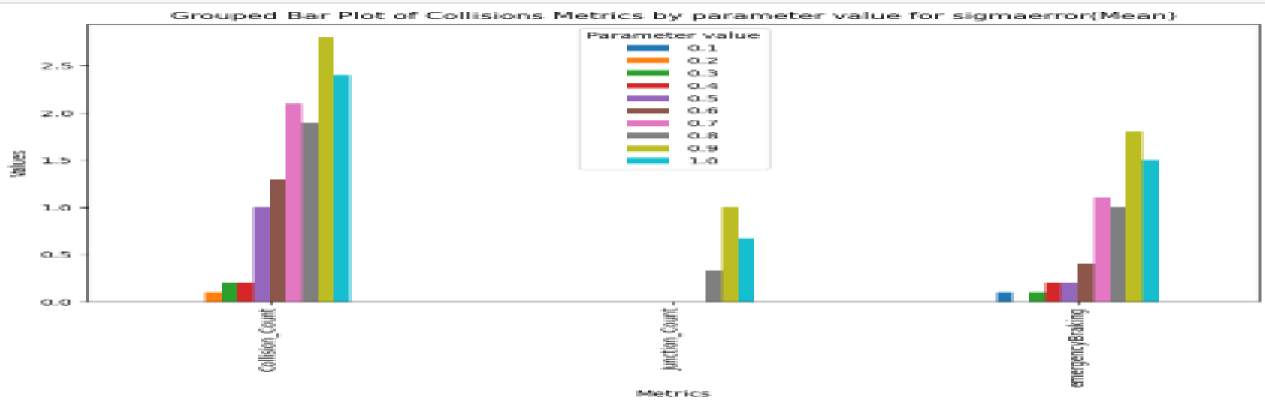
Grouped Bar Plot of Collisions Metrics by parameter value for sigmaerror:

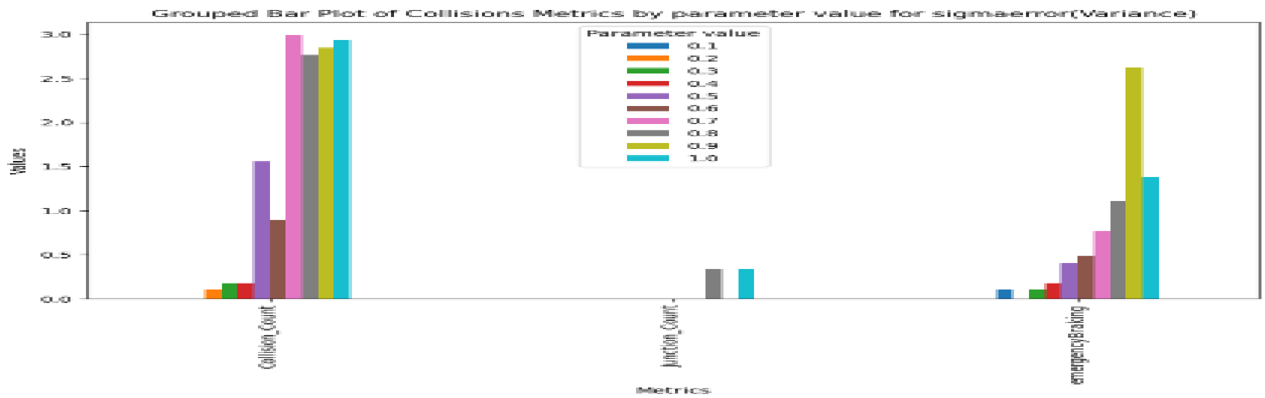
In the analysis of the "sigmaerror" parameter, several critical findings emerge regarding the simulated traffic scenarios. The "Collisions" data reveals a clear upward trend as the "sigmaerror" value increases from 0.1 to 1, indicating a positive correlation between "sigmaerror" and the frequency of collisions in the simulations. This pattern is similarly mirrored in the "Collision_Count," where an increase in "sigmaerror" leads to a rise in the count of collisions, reinforcing the link between this parameter and collision incidents.

Surprisingly, "Junction_Count" remains consistent at zero across all "sigmaerror" values, suggesting that variations in "sigmaerror" do not significantly impact the number of junction incidents within the simulations. This intriguing observation implies that other parameters or factors might be more influential in determining junction-related events.

Furthermore, the "Emergency Braking" incidents exhibit an increasing trend with higher "sigmaerror" values, ranging from 0.1 to 1.5. This finding underscores the connection between "sigmaerror" and the occurrence of emergency braking events within the simulated scenarios.

In summary, the "sigmaerror" parameter distinctly influences "Collisions," "Collision_Count," and "Emergency Braking" incidents, demonstrating a heightened frequency of these events as "sigmaerror" values increase. However, the stability of "Junction_Count" across "sigmaerror" values suggests that other factors might play a more dominant role in governing junction-related incidents. These insights underscore the importance of precise parameter selection in shaping specific aspects of simulation outcomes.



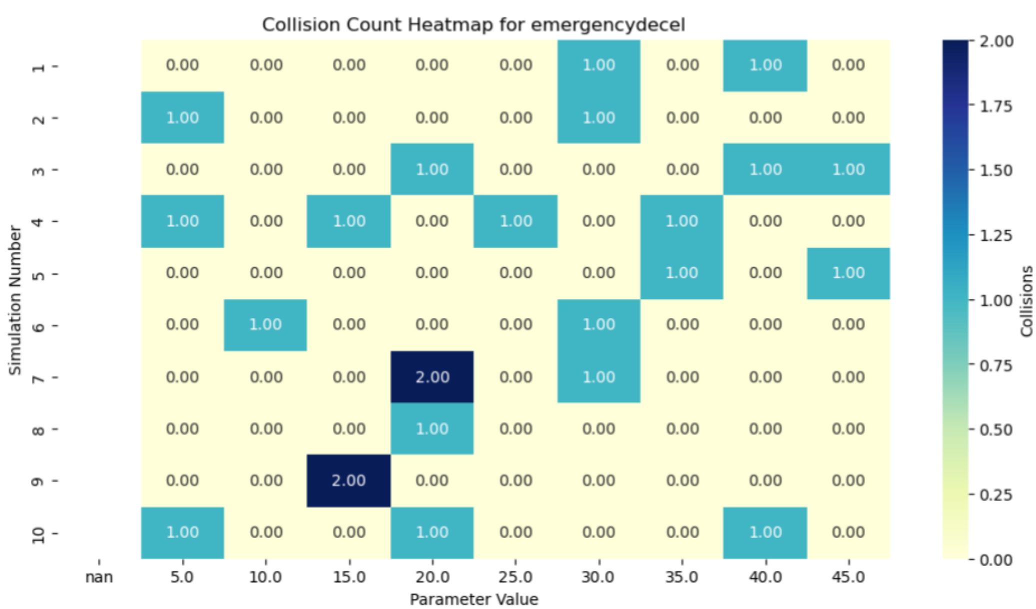


EmergencyDecel:

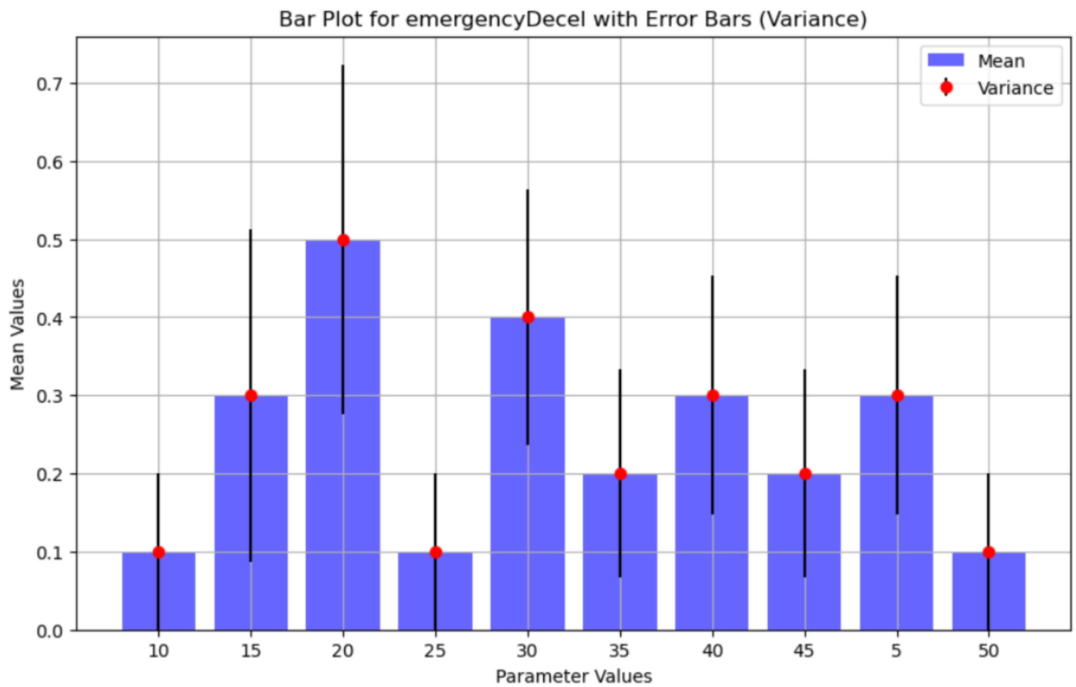
Collision Count Heatmap:

The heatmap, which is like a color-coded grid, to help us see how collisions change across different simulations and for different values of a parameter (in this case, " emergencyDecel "). The rows in the heatmap represent different simulations, and the columns represent different parameter values.

The color of each cell in the heatmap shows the number of collisions in a particular simulation with a specific parameter value. Darker colors indicate more collisions, while lighter colors mean fewer collisions. This way, we can easily see which parameter values and simulations lead to more or fewer collisions.



Collision Count Bar Plot for EmergencyDecel:



Mean Analysis:
When examining the "Collisions" data with varying "emergency decel" values, we find that there is no consistent trend in how this parameter affects the mean number of collisions. The mean collision counts fluctuate across different "emergency decel" settings, indicating that changes in this parameter have a limited impact on the average collision rate.

Variance Analysis:
The variance analysis shows that the spread or variability in collision counts remains consistently low across simulations with different "emergency decel" values. This suggests that while the mean collision counts may vary slightly, the variability in collision outcomes remains stable. In summary, "emergency decel" adjustments have a minor influence on both the mean and variance of collision occurrences, indicating its limited impact on collision outcomes in the simulated scenarios.

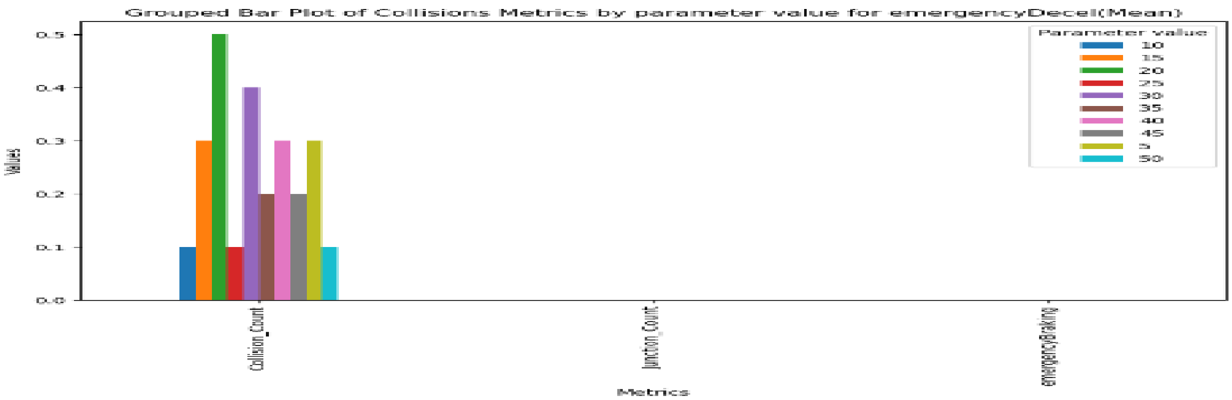
Grouped Bar Plot of Collisions Metrics by parameter value for EmergencyDecel:

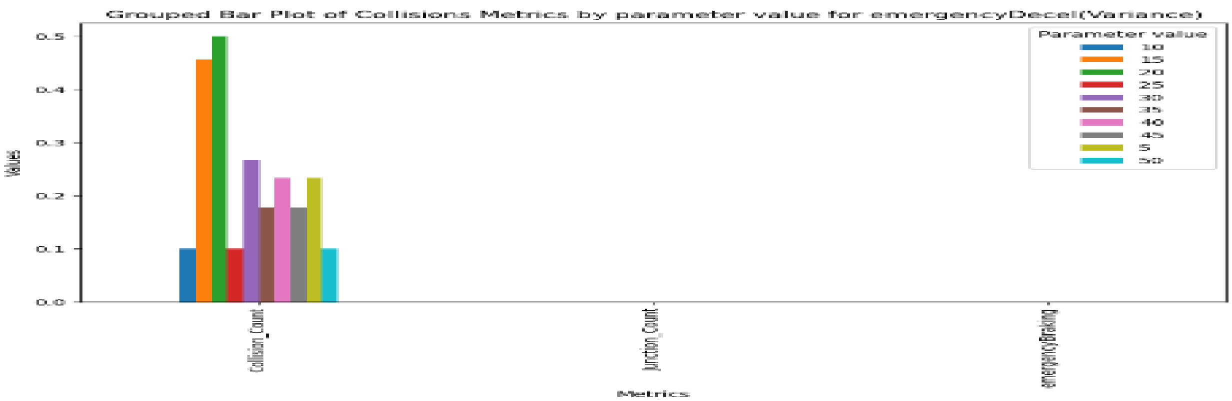
Mean Analysis:
For "Collision Count," increasing "Emergency Decel" values from 5 to 50 lead to a higher mean collision count, indicating a direct positive correlation. Simulations with more aggressive deceleration exhibit more collisions on average.

When examining "Emergency Decel" on "Junction Count," the mean "Junction Count" also increases as "Emergency Decel" values rise. This suggests a direct relationship between the parameter and more frequent junction occurrences.

Variance Analysis:
In both "Collision Count" and "Junction Count," increasing "Emergency Decel" values result in higher variances. This means not only more frequent collisions and junction occurrences but also a wider range of outcomes in different simulations.

In summary, higher "Emergency Decel" values lead to more collisions and junctions on average and a broader range of outcomes across simulations. Parameter selection significantly influences these simulation outcomes.



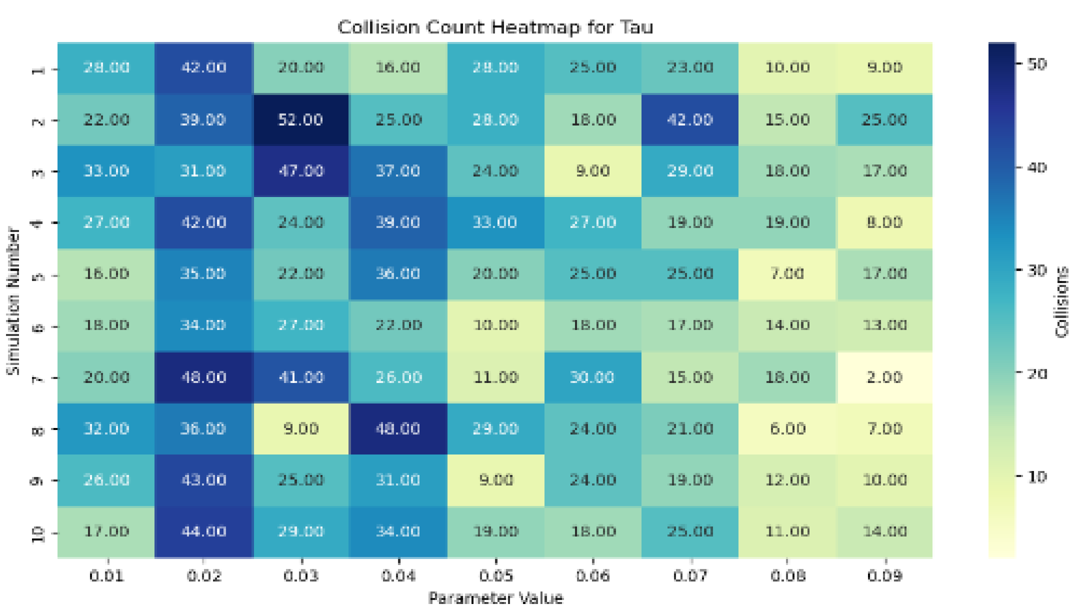


Tau:

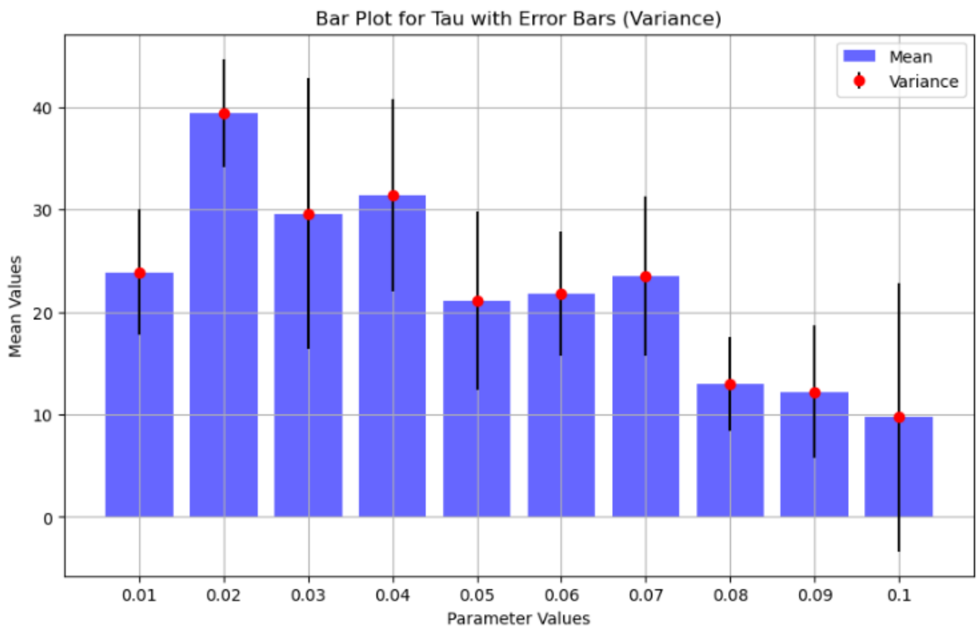
Collision Count Heatmap:

The heatmap, which is like a color-coded grid, to help us see how collisions change across different simulations and for different values of a parameter (in this case, " tau "). The rows in the heatmap represent different simulations, and the columns represent different parameter values.

The color of each cell in the heatmap shows the number of collisions in a particular simulation with a specific parameter value. Darker colors indicate more collisions, while lighter colors mean fewer collisions. This way, we can easily see which parameter values and simulations lead to more or fewer collisions.



Collision Count Bar Plot for Tau:



Mean Analysis:
As the "Tau" value increases from 0.01 to 0.1, there is a noticeable decrease in the mean "Collision Count". This indicates an inverse relationship between "Tau" and the average number of collisions. Higher "Tau" values lead to a reduction in collisions.

For the "Emergency Braking" parameter, it's evident that higher values are associated with a decrease in the mean "Collision Count". This suggests that increased emergency braking tends to mitigate collisions during simulations.

The mean "Junction Count" doesn't show a clear trend with "Tau" values. It fluctuates, indicating no consistent relationship between "Tau" and the average junction occurrences.

Variance Analysis:
Looking at the variances in "Collision Count", they remain relatively low and consistent across different "Tau" values. This implies that the variability in collision outcomes is not significantly affected by changes in "Tau".

In contrast, the variance in "Emergency Braking" demonstrates a decreasing trend as "Tau" values increase. This suggests that higher "Tau" values contribute to more predictable outcomes regarding emergency braking and its effect on collisions.

Grouped Bar Plot of Collisions Metrics by parameter value for Tau:

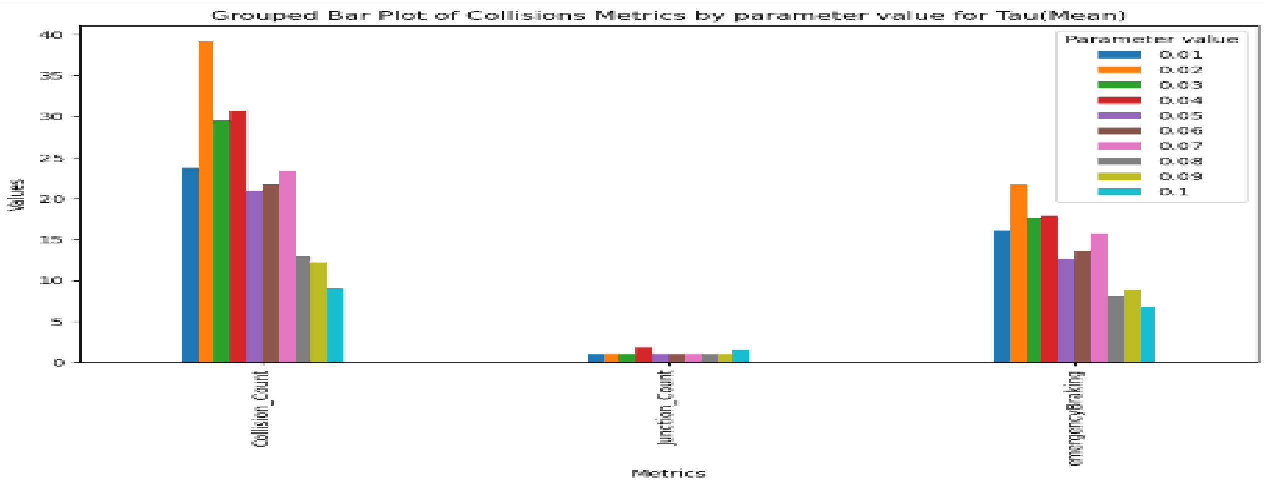
Mean Analysis:
The "Collision Count" decreases as "Tau" values rise from 0.01 to 0.1, indicating a negative correlation between "Tau" and collision count. Simulations with higher "Tau" values exhibit less collisions on average.

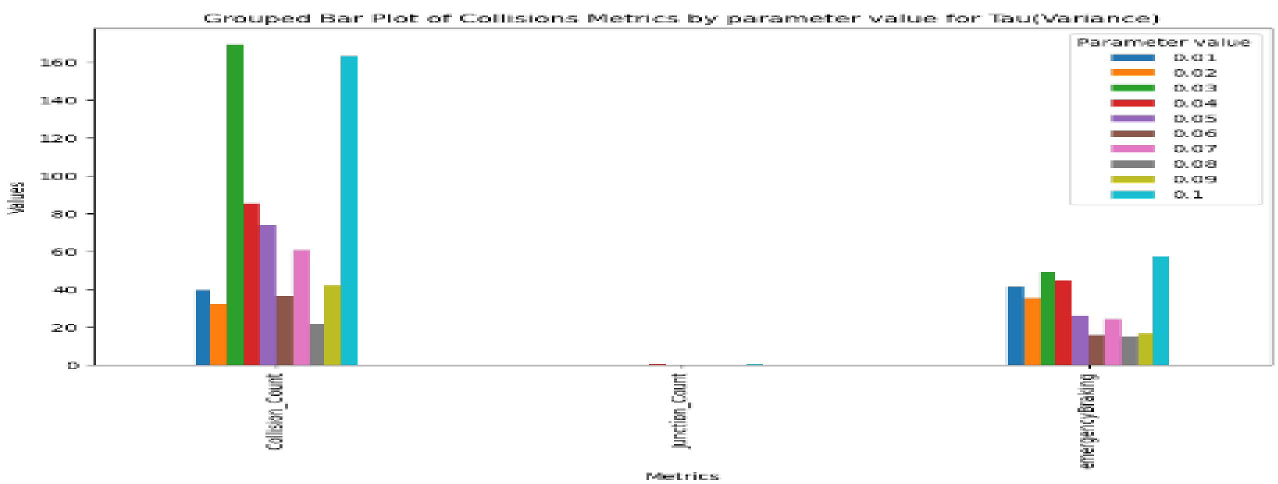
For "Junction Count," the mean increases as "Tau" values go up. This implies that higher "Tau" values lead to more frequent junction occurrences in simulations.

Variance Analysis:
In "Collision Count," the variance is generally low and remains consistent across "Tau" values. This suggests that simulation outcomes are relatively predictable and stable in terms of collisions.

For "Junction Count," as "Tau" values increase, the variance remains low and consistent. This suggests that junction occurrences are more predictable, and the variance is not significantly influenced by "Tau."

In summary, "Tau" has a positive correlation with "Collision Count," Variance is generally low for "Junction Count," indicating consistent results. These findings emphasize the importance of parameter selection in simulation outcomes.


Grouped Bar Plot of Collisions Metrics by parameter value for Tau(Mean)
Parameter value
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Values
Collision_Count
Junction_Count
emergencyBraking
Metrics


Grouped Bar Plot of Collisions Metrics by parameter value for Tau(Variance)
Parameter value
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Values
Collision_Count
Junction_Count
emergencyBraking
Metrics

SCENARIO 1 - Examining the different vehicle types which were presented in the paper and try to recreate the same parameters using sumo configuration.

The paper discusses the variation of specific parameters within the Intelligent Driver Model (IDM) to represent different driver behaviors in a simulated traffic environment. The IDM parameters that are being varied are as follows:

Desired Speed (vdes): This parameter represents the speed at which a vehicle aims to travel under normal conditions. Different driver behaviors may be modeled by varying this desired speed.

Minimum Headway Distance (dmin): Dmin represents the minimum safe following distance that a vehicle maintains from the vehicle in front. Varying this parameter can simulate different levels of aggressiveness or caution in maintaining safe distances.

Desired Time Headway (τ): τ represents the desired time gap between a vehicle and the one in front. This parameter influences how quickly a vehicle adjusts its speed in response to changes in the traffic situation.

Maximum Acceleration (amax): Amax is the maximum rate at which a vehicle can increase its speed. Varying this parameter can capture different acceleration profiles, such as aggressive or conservative acceleration behaviors.

Comfortable Deceleration (bcomf): Bcomf represents the rate at which a vehicle can comfortably slow down. It plays a role in determining how quickly a vehicle decelerates when needed.

Sumo Configuration:

Vehicle Type	Car Follow Model	Max Speed	Acceleration	Deceleration	Min Gap	Tau	Color
Passive	IDM	10	1	1	5	1.75	0.0, 0.0, 1.0
Aggressive	IDM	30	5	5	1	0.25	1.0, 0.0, 0.0
Tailgater	IDM	15	1	1	1	0.25	0.0, 1.0, 0.0
Speeder	IDM	30	5	5	5	1.75	1.0, 1.0, 0.0

1. `id` (e.g., "passive," "aggressive," "tailgater," "speeder"): This is a unique identifier for each vehicle type. It allows you to reference and use this specific type of vehicle in your simulation.

2. `carFollowModel` (e.g., "IDM"): It specifies the car-following model used for the vehicles of this type. In this case, "IDM" stands for the Intelligent Driver Model, which is a model used to simulate vehicle behavior in traffic flow.

3. `maxSpeed` : This parameter defines the maximum speed in meters per second (m/s) that a vehicle of this type can reach.

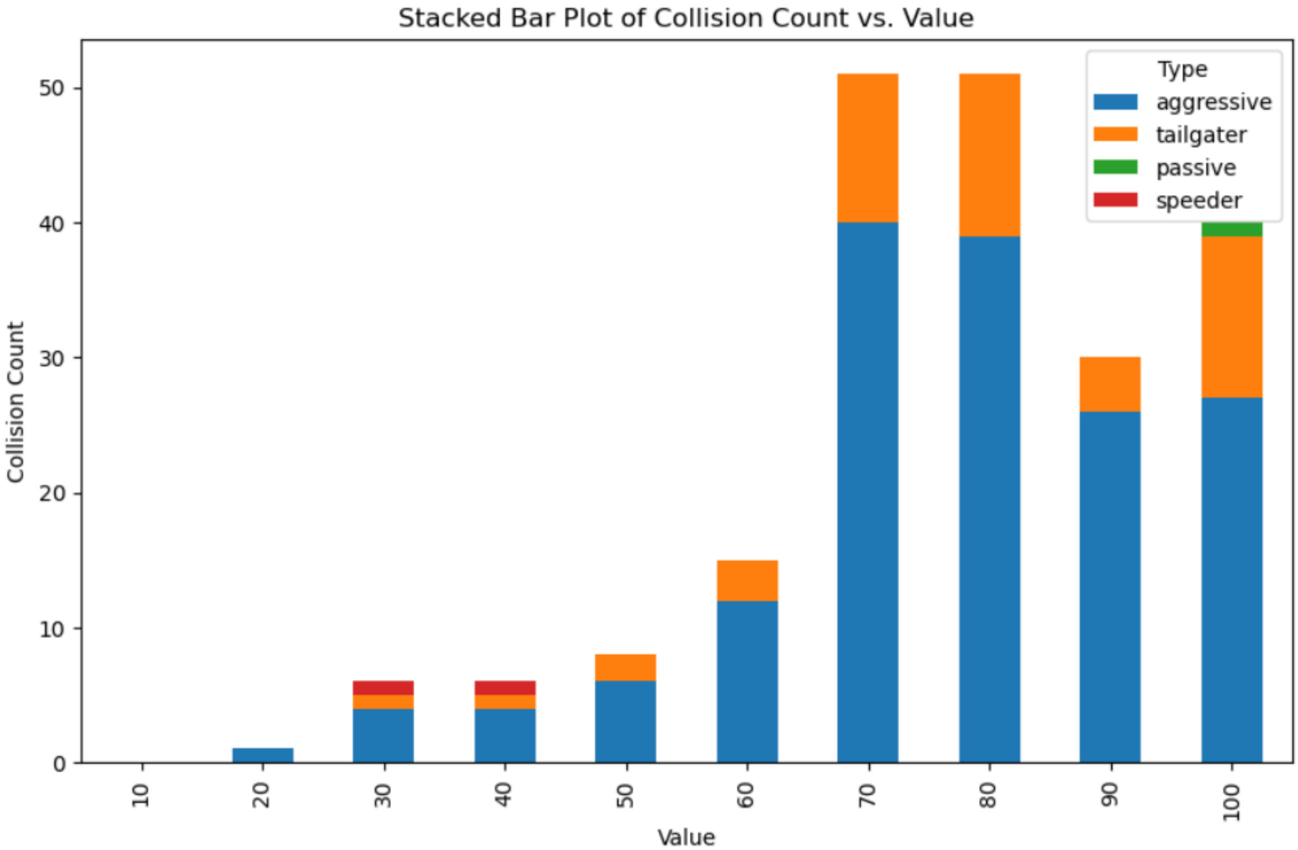
4. `accel` : It represents the acceleration capability of the vehicle type, which is the rate at which the vehicle can increase its speed in m/s^2.

5. `decel` : This parameter specifies the deceleration capability of the vehicle type, which is the rate at which the vehicle can decrease its speed in m/s^2.

6. `minGap` : It defines the minimum desired gap (in meters) that a vehicle of this type maintains to the vehicle in front while following in traffic.

7. `tau` : The parameter tau in the IDM (Intelligent Driver Model) represents the driver's desired time headway, which is the minimum time they want to maintain as a safety buffer between their vehicle and the vehicle in front of them.

These parameters are used to define and customize different types of vehicles in your traffic simulation, allowing you to specify their characteristics and behavior within the simulation environment.



Aggressive Vehicles:

There is a clear upward trend in collision counts as the number of vehicles on the road increases. This indicates that the aggressive vehicles tend to be involved in more collisions as traffic becomes more congested.
At the lowest vehicle count (10), there are no collisions involving aggressive vehicles. However, this number increases steadily, reaching 40 collisions when the number of vehicles reaches 70.

Tailgater Vehicles:

Similar to the aggressive vehicles, tailgater vehicles also exhibit an increasing trend in collision counts as the number of vehicles on the road increases.
Just like the aggressive vehicles, tailgater vehicles also start with 0 collisions at 10 vehicles and increase to 12 collisions at 80 vehicles.

Passive Vehicles:

The data provided for passive vehicles lacks collision count information, making it impossible to discern any trends or behaviors for this vehicle type. Further data is required to understand how passive vehicles interact with different traffic conditions.

Speeder Vehicles:

The speeder vehicles' behavior differs from the other types. They begin with 0 collisions at 10 vehicles, and at 30 vehicles, there is only 1 collision reported. After this point, no further collision data is provided for speeder vehicles.
This trend suggests that speeder vehicles may perform well under low to moderately congested traffic conditions, but their behavior beyond 30 vehicles is uncertain due to the lack of data.

Key Takeaways:

Both aggressive and tailgater vehicles tend to be involved in more collisions as traffic congestion increases. This might be attributed to their driving behaviors, which could be riskier or less considerate of safe following distances.
The lack of collision data for passive vehicles makes it challenging to draw any conclusions about their collision behavior.
Speeder vehicles exhibit a unique trend, with low collision counts at the start, but without more data.